Claims

What is claimed is:

1. A method for controlling a Variable Air Volume (VAV) box in a pressure independent VAV temperature control system comprising:

receiving an indication of an airflow setpoint;

measuring an airflow in the VAV box and calculating an error between the airflow setpoint and the measured airflow; and

until a new airflow setpoint indication is received, repeating the steps comprising:

based on the error, predicting a damper runtime to move a damper in the VAV box to achieve the airflow setpoint,

if the predicted damper runtime is less than a minimum runtime, not moving the damper and measuring the airflow to calculate an average airflow over a period of time,

if the predicted damper runtime is not less than the minimum runtime, measuring the airflow in the VAV box while moving the damper for the predicted damper runtime or until the airflow is measured to have crossed the airflow setpoint,

in response to moving the damper, measuring the airflow to calculate the average airflow, and

based on the average airflow, recalculating the error.

2. A computer-readable medium having stored thereon computer-executable instructions for performing the method of claim 1.

3. The method of claim 1, wherein the predicted damper runtime is determined by dividing the error by a slope of a damper response curve.

4. The method of claim 3, further comprising:

in response to moving the damper and calculating the average airflow, determining how long the damper was moved and calculating a new slope of the damper response curve;

in response to determining that the damper was moved for less than a second minimum runtime, disregarding the new slope and using the previous

slope to recalculate the error;

in response to determining that the damper was moved for a duration within a predetermined runtime range, averaging the new slope with the previous slope and using the averaged slope to recalculate the error; and

in response to determining that the damper was moved for longer than the predetermined runtime range, using the new slope to recalculate the error.

5. A computer-readable medium having stored thereon computer-executable instructions for performing the method of claim 4.

6. The method of claim 1, wherein moving the damper for the predicted damper runtime or until the airflow is measured to have crossed the airflow setpoint comprises:

in response to determining that the predicted damper runtime is not greater than a second minimum runtime, moving the damper for the predicted runtime; and

in response to determining that the predicted damper runtime is greater than the second minimum runtime, moving the damper until the airflow is measured to have crossed the airflow setpoint.

7. The method of claim 1, further comprising, in response to receiving the airflow setpoint indication, calculating a percent change between the airflow setpoint and a previous airflow setpoint; and

in response to determining that the percent change is greater than a predetermined percent change, replacing the previous airflow setpoint with the airflow setpoint.

8. The method of claim 1, wherein the airflow setpoint is calculated using a digital PID control having a proportional term, an integral term and a derivative term, the digital PID control comprising:

receiving a room temperature measurement and calculating a temperature error between the room temperature and a temperature setpoint;

in response to determining that the temperature error is greater than a temperature threshold, calculating the airflow setpoint using a significantly increased or a significantly decreased PID output and accumulating the integral term;

after the expiration of a time increment, re-measuring the room temperature and recalculating the temperature error;

in response to determining that the temperature error is less than the temperature threshold, determining whether the temperature error is within a deadband of the temperature setpoint;

in response to determining that the temperature error is within the deadband of the temperature setpoint, recalculating the PID output by updating the proportional term but not updating the integral term and calculating the airflow setpoint using the recalculated PID output; and

in response to determining that the temperature error is not within the deadband of the temperature setpoint, recalculating the PID output by updating the proportional term and the integral term and calculating the airflow setpoint using the recalculated PID output.

9. A computer-readable medium having stored thereon computer-executable instructions for performing the method of claim 8.

10. The method of claim 8, wherein the significantly increased PID output is used in a cooling situation; and

wherein the significantly increased PID output comprises one hundred percent.

11. The method of claim 8, wherein the significantly decreased PID output is used in a heating situation; and

wherein the significantly increased PID output comprises zero percent.

12. A pressure independent Variable Air Volume (VAV) temperature control system comprising:

a VAV box having an airflow control damper for controlling an airflow delivered to a room and an airflow sensor for measuring the airflow;

a temperature sensor within the room for measuring a temperature of the room; and

a micro-controller configured for executing computer-executable instructions for:

receiving a room temperature measurement from the temperature sensor and using the temperature measurement to calculate an airflow setpoint,

receiving an airflow measurment from the airflow sensor and calculating an error between the airflow setpoint and the airflow measurment, and

until a new room temperature measurement is received from the temperature sensor and a new airflow setpoint is calculated, repeating the steps comprising:

based on the error, predicting a damper runtime to move the damper in the VAV box to achieve the airflow setpoint,

if the predicted damper runtime is less than a minimum runtime, not generating a signal for moving the damper and receiving airflow measurements from the airflow sensor to calculate an average airflow over a period of time,

if the predicted damper runtime is not less than the minimum runtime, receiving airflow measurements from the airflow sensor while generating the signal for moving the damper for the predicted damper runtime or until one of the airflow measurements is determined to have crossed the airflow setpoint,

in response to movement of the damper, receiving airflow measurements from the airflow sensor to calculate the average airflow, and

based on the average airflow, recalculating the error.

13. The system of claim 12, wherein the predicted damper runtime is determined by dividing the error by a slope of a damper response curve.

14. The system of claim 13, wherein the micro-controller further executes computer-executable instructions comprising:

in response to movement of the damper and calculation of the average airflow, determining how long the damper was moved and calculating a new slope of the damper response curve;

in response to determining that the damper was moved for less than a second minimum runtime, disregarding the new slope and using the previous slope to recalculate the error;

in response to determining that the damper was moved for a duration within a predetermined runtime range, averaging the new slope with the previous slope and using the averaged slope to recalculate the error; and

in response to determining that the damper was moved for longer than the predetermined runtime range, using the new slope to recalculate the error.

15. The system of claim 12, wherein generating the signal for moving the damper for the predicted damper runtime or until the airflow is measured to have crossed the airflow setpoint comprises:

in response to determining that the predicted damper runtime is not greater than a second minimum runtime, generating the signal for moving the damper for the predicted runtime; and

in response to determining that the predicted damper runtime is greater than the second minimum runtime, generating the signal for moving the damper until the airflow is measured to have crossed the airflow setpoint.

16. The system of claim 12, wherein the micro-controller further executes computer-executable instructions comprising:

in response to calculating the airflow setpoint, calculating a percent change between the airflow setpoint and a previous airflow setpoint; and

in response to determining that the percent change is greater than a predetermined percent change, replacing the previous airflow setpoint with the airflow setpoint.

17. The system of claim 12, wherein the airflow setpoint is calculated using a digital PID control having a proportional term, an integral term and a

derivative term, the digital PID control comprising computer-executable instructions for:

in response to receiving the room temperature measurement, calculating a temperature error between the room temperature and a temperature setpoint;

in response to determining that the temperature error is greater than a temperature threshold, calculating the airflow setpoint using a significantly increased PID output and accumulating the integral term;

after the expiration of a time increment, receiving a new room temperature measurement and using the new room temperature measurement to recalculate the temperature error;

in response to determining that the temperature error is less than the temperature threshold, determining whether the temperature error is within a deadband of the temperature setpoint;

in response to determining that the temperature error is within the deadband of the temperature setpoint, recalculating the PID output by updating the proportional term but not updating the integral term and calculating the airflow setpoint using the recalculated PID output; and

in response to determining that the temperature error is not within the deadband of the temperature setpoint, recalculating the PID output by updating the proportional term and the integral term and calculating the airflow setpoint using the recalculated PID output.

18. The system of claim 17, wherein the significantly increased PID output is used in a cooling situation; and

wherein the significantly increased PID output comprises one hundred percent.

19. The system of claim 17, wherein the significantly decreased PID output is used in a heating situation; and

wherein the significantly increased PID output comprises zero percent.

20. A method for controlling a Variable Air Volume (VAV) box in a pressure independent VAV temperature control system, the method relying on a PID control having a proportional term, an integral term and a derivative term, the method comprising:

receiving a room temperature measurement and calculating a temperature error between the room temperature and a temperature setpoint;

in response to determining that the temperature error is greater than a temperature threshold, calculating the airflow setpoint using a significantly increased PID output and accumulating the integral term;

after the expiration of a time increment, re-measuring the room temperature and recalculating the temperature error;

in response to determining that the temperature error is less than the temperature threshold, determining whether the temperature error is within a deadband of the temperature setpoint;

in response to determining that the temperature error is within the deadband of the temperature setpoint, recalculating the PID output by updating the proportional term but not updating the integral term and calculating the airflow setpoint using the recalculated PID output; and

in response to determining that the temperature error is not within the deadband of the temperature setpoint, recalculating the PID output by updating the proportional term and the integral term and calculating the airflow setpoint using the recalculated PID output.

21. A computer-readable medium having stored thereon computer-executable instructions for performing the method of claim 20.

22. The method of claim 20, wherein the significantly increased PID output is used in a cooling situation; and

wherein the significantly increased PID output comprises one hundred percent.

23. The method of claim 20, wherein the significantly decreased PID output is used in a heating situation; and

wherein the significantly increased PID output comprises zero percent.

24. The method of claim 20, further comprising:

in response to calculating the airflow setpoint, measuring an airflow in the VAV box and calculating an error between the airflow setpoint and the measured airflow; and

until a new airflow setpoint is cauculated, repeating the steps comprising:

based on the error, predicting a damper runtime to move a damper in the VAV box to achieve the airflow setpoint,

if the predicted damper runtime is less than a minimum runtime, not moving the damper and measuring the airflow to calculate an average airflow over a period of time,

if the predicted damper runtime is not less than the minimum runtime, measuring the airflow in the VAV box while moving the damper for the predicted damper runtime or until the airflow is measured to have crossed the airflow setpoint,

in response to moving the damper, measuring the airflow to calculate the average airflow, and

based on the average airflow, recalculating the error.

25. A computer-readable medium having stored thereon computer-executable instructions for performing the method of claim 24.

26. The method of claim 24, wherein the predicted damper runtime is determined by dividing the error by a slope of a damper response curve.

27. The method of claim 24, further comprising:

in response to moving the damper and calculating the average airflow, determining how long the damper was moved and calculating a new slope of the damper response curve;

in response to determining that the damper was moved for less than a second minimum runtime, disregarding the new slope and using the previous slope to recalculate the error;

in response to determining that the damper was moved for a duration within a predetermined runtime range, averaging the new slope with the previous slope and using the averaged slope to recalculate the error; and

in response to determining that the damper was moved for longer than the predetermined runtime range, using the new slope to recalculate the error.

28. A computer-readable medium having stored thereon computer-executable instructions for performing the method of claim 27.

29. The method of claim 24, wherein moving the damper for the predicted damper runtime or until the airflow is measured to have crossed the airflow setpoint comprises:

in response to determining that the predicted damper runtime is not greater than a second minimum runtime, moving the damper for the predicted runtime; and

in response to determining that the predicted damper runtime is greater than the second minimum runtime, moving the damper until the airflow is measured to have crossed the airflow setpoint.

30. The method of claim 24, further comprising, in response to receiving the airflow setpoint indication, calculating a percent change between the airflow setpoint and a previous airflow setpoint; and

in response to determining that the percent change is greater than a predetermined percent change, replacing the previous airflow setpoint with the airflow setpoint.

31. A pressure independent Variable Air Volume (VAV) temperature control system comprising:

a VAV box having an airflow control damper for controlling an airflow delivered to a room and an airflow sensor for measuring the airflow;

a temperature sensor within the room for measuring a temperature of the room; and

a micro-controller configured for executing computer-executable instructions for performing a PID control having a proportional term, an integral term and a derivative term, the computer-executable instructions comprising:

in response to receiving a room temperature measurement, calculating a temperature error between the room temperature and a temperature setpoint;

in response to determining that the temperature error is greater than a temperature threshold, calculating an airflow setpoint using a significantly increased PID output and accumulating the integral term;

after the expiration of a time increment, receiving a new room temperature measurement and using the new room temperature measurement to recalculate the temperature error;

in response to determining that the temperature error is less than the temperature threshold, determining whether the temperature error is within a deadband of the temperature setpoint;

in response to determining that the temperature error is within the deadband of the temperature setpoint, recalculating the PID output by updating the proportional term but not updating the integral term and calculating the airflow setpoint using the recalculated PID output; and

in response to determining that the temperature error is not within the deadband of the temperature setpoint, recalculating the PID output by updating the proportional term and the integral term and calculating the airflow setpoint using the recalculated PID output.

32. The system of claim 31, wherein the significantly increased PID output is used in a cooling situation; and

wherein the significantly increased PID output comprises one hundred percent.

33. The system of claim 31, wherein the significantly decreased PID output is used in a heating situation; and

wherein the significantly increased PID output comprises zero percent.

34. The system of claim 31, wherein the micro-controller further executes computer-executable instructions comprising:

in response to receiving the airflow setpoint, receiving an airflow measurment from the airflow sensor and calculating an error between the airflow setpoint and the airflow measurment; and

until a new room temperature measurement is received from the temperature sensor and a new airflow setpoint is calculated, repeating the steps comprising:

based on the error, predicting a damper runtime to move the damper in the VAV box to achieve the airflow setpoint,

if the predicted damper runtime is less than a minimum runtime, not generating a signal for moving the damper and receiving airflow measurements from the airflow sensor to calculate an average airflow over a period of time,

if the predicted damper runtime is not less than the minimum runtime, receiving airflow measurements from the airflow sensor while generating the signal for moving the damper for the predicted damper runtime or until one of the airflow measurements is determined to have crossed the airflow setpoint,

in response to movement of the damper, receiving airflow measurements from the airflow sensor to calculate the average airflow, and

based on the average airflow, recalculating the error.

35. The system of claim 34, wherein the predicted damper runtime is determined by dividing the error by a slope of a damper response curve.

36. The system of claim 35, wherein the micro-controller further executes computer-executable instructions comprising:

in response to movement of the damper and calculation of the average airflow, determining how long the damper was moved and calculating a new slope of the damper response curve;

in response to determining that the damper was moved for less than a second minimum runtime, disregarding the new slope and using the previous

slope to recalculate the error;

in response to determining that the damper was moved for a duration within a predetermined runtime range, averaging the new slope with the previous slope and using the averaged slope to recalculate the error; and

in response to determining that the damper was moved for longer than the predetermined runtime range, using the new slope to recalculate the error.

37. The system of claim 34, wherein generating the signal for moving the damper for the predicted damper runtime or until the airflow is measured to have crossed the airflow setpoint comprises:

in response to determining that the predicted damper runtime is not greater than a second minimum runtime, generating the signal for moving the damper for the predicted runtime; and

in response to determining that the predicted damper runtime is greater than the second minimum runtime, generating the signal for moving the damper until the airflow is measured to have crossed the airflow setpoint.

38. The system of claim 34, wherein the micro-controller further executes computer-executable instructions comprising:

in response to calculating the airflow setpoint, calculating a percent change between the airflow setpoint and a previous airflow setpoint; and

in response to determining that the percent change is greater than a predetermined percent change, replacing the previous airflow setpoint with the airflow setpoint.